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NOTIFICATION OF ELECTION

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Applicant

CANNING, John

1. The designated Office is hereby notified of its election made:

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2. The election [X] was

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   made before the expiration of 19 months from the priority date or, where Rule 32 applies, within the time limit under Rule 32.2(b).

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Optical Device and Process

Field of the invention

The present invention relates broadly to an optical
device comprising a waveguide and a process for fabricating
5   the same.

Background of the invention

In optical waveguides it is often desirable to direct
light around bends, for example to reduce the size of
devices incorporating optical waveguides. An inherent
10   problem is, however, that due to the refractive index
properties of the waveguide and the material surrounding
the waveguide, it is likely that light will be diffracted
out of bends, in particular tight bends, thereby resulting
in what is commonly referred to as bending losses. Such
15   losses can limit the performance of the device.

The directing of light signals in different directions
would also be desirable in devices where it is required to
confine light to a predetermined path within the waveguide,
for example in optical filter or optical resonator
20   structures.

Summary of the Invention

The present invention provides an optical waveguide
structure comprising:

-       an optical waveguide having a bend and being
25   formed of a photosensitive material; and
-       a grating structure arranged to guide light of a
predetermined wavelength around the bend in the waveguide,
the grating structure comprising UV-induced refractive
index variations in the waveguide.

30   A substantial reduction in bending loss can be
achieved by guiding light around the bend with the grating
structure.

The present invention allows for angular dispersion to
be added to a propagating light signal which can be
35   controlled by the properties of the grating structures.

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For example, this can be utilised for dispersion compensation, pulse shirping, or pulse compressing. This is because different wavelengths see a different angular path with respect to the grating structure.

5   The device may be utilised in complex light manipulation circuits both in the spectral and time domain.

The grating structure may comprise a chirped grating.

The grating structure may be disposed to direct the light in a reflection or in a transmission mode.

10   Because of an angular dependence of the accepted wavelength in the grating, the device can depend on angular sweep to isolate wavelengths or signals.

The grating structure may comprise a continuous grating. Alternatively, the grating structure may comprise

15   two gratings which mirror each other.

In one embodiment, the grating structure comprises regions of constant refractive index which extent in the propagation direction of the waveguide.

The regions may extend parallel to the propagation

20   direction.

The regions may extend cylindrically parallel to the propagation direction.

The regions may extend ellipsoidally parallel to the propagation direction.

25   The device may further comprise at least one optical reflector disposed in a direction transverse to the propagation direction to aid in confining the light to the path.

The device may comprise two or more grating structures

30   angularly disposed with respect to each other to guide light around the bend.

Accordingly, different confinement conditions may be realised at different boundaries of the waveguide.

The grating structures may be formed by UV-holography.

35   The gratings may be chirped gratings.

The gratings may be sampled gratings.

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The device may be a filter, a resonator, or a sensor.

In one embodiment, the device is a sensor further comprising means for measuring an intensity of the light at a predetermined point along the waveguide for determining

5   changes in the intensity due to induced changes in confinement conditions of the sensor.

The changes may be induced by gas molecules entering the waveguide.

The present invention may alternatively be defined as

10   providing a method of adapting a photosensitive waveguide to guide light of a predetermined wavelength around a bend in the waveguide, comprising:

- using UV light to induce refractive index variations in the waveguide such that at least one grating structure is

15   formed, wherein the grating structure is disposed to guide the light around the bend.

Preferred forms of the invention will now be described, by way of example only, with reference to the accompanying drawings, in which:

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(54) Title: OPTICAL WAVEGUIDE STRUCTURE

(57) Abstract

An optical device comprising a waveguide structure (1), at least one grating structure (4) formed in the waveguide structure, and the grating structure being disposed to direct along a selected path (5) in the waveguide structure light of a predetermined wavelength entering the waveguide structure at a predetermined angle of incidence to the grating structure.

Optical Device and Process

Field of the invention

The present invention relates broadly to an optical
device comprising a waveguide and a process for fabricating
the same.

Background of the invention

In optical waveguides it is often desirable to direct
light around bends, for example to reduce the size of
devices incorporating optical waveguides. An inherent
problem is, however, that due to the refractive index
properties of the waveguide and the material surrounding
the waveguide, it is likely that light will be diffracted
out of bends, in particular tight bends, thereby resulting
in what is commonly referred to as bending losses. Such
losses can limit the performance of the device.

The directing of light signals in different directions
would also be desirable in devices where it is required to
confine light to a predetermined path within the waveguide,
for example in optical filter or optical resonator
structures.

Summary of the Invention

The present invention provides an optical device
comprising a waveguide structure, at least one grating
structure formed in the waveguide structure; the grating
structure being disposed to direct along a selected path in
the waveguide structure light of a predetermined wavelength
entering the waveguide structure at a predetermined angle
of incidence to the grating structure.

As the light directing is achieved by utilising the
grating structure, a substantial reduction in bending loss
can be achieved.

The waveguide structure may be formed from
photosensitive material, and the grating structure may be
formed by UV-induced refractive index variations in the
waveguide.

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The present invention allows for angular dispersion to be added to a propagating light signal which can be controlled by the properties of the grating structures. This can be utilised for e.g. dispersion compensation, pulse shirping, or pulse compressing. This is because different wavelengths see a different angular path with respect to the grating structure.

The device may be utilised in complex light manipulation circuits both in the spectral and time domain.

The grating structure may comprise a chirped grating.

The grating structure may be disposed to direct the light in a reflection or in a transmission mode.

The present invention may alternatively be defined as providing an optical device comprising a waveguide of photosensitive material; at least one grating structure formed by UV-induced refractive index variations in the waveguide; the grating structure being disposed to confine to a selected path in the waveguide light of a predetermined wavelength entering the waveguide at a predetermined angle of incidence to the grating structure.

Because of the angular dependence of the accepted wavelength in the grating confined waveguide such devices can e.g. depend on angular sweep to isolate wavelengths or signals.

The grating structure may comprise a continuos grating. Alternatively, the grating structure may comprise two gratings which mirror each other.

In one embodiment, the grating structure comprises regions of constant refractive index which extent in the propagation direction of the waveguide.

The regions may extend parallel to the propagation direction.

The regions may extend cylindrically parallel to the propagation direction.

The regions may extend elipsoidically parallel to the propagation direction.

The device may further comprise at least one optical reflector disposed in a direction transverse to the propagation direction to aid in confining the light to the path.

The device may comprise two or more grating structures angularly disposed with respect to each other to channel the light around the selected path.

Accordingly, different confinement conditions may be realised at different boundaries of the waveguide.

The grating structures may be formed by UV-holography.

The gratings may be chirped gratings.

The gratings may be sampled gratings.

The device may be a filter, a resonator, or a sensor.

In one embodiment, the device is a sensor further comprising means for measuring an intensity of the light at a predetermined point along the selected path for determining changes in the intensity due to induced changes in confinement conditions of the sensor.

The changes may be induced by gas molecules entering the waveguide.

The present invention may alternatively be defined as providing a process for fabricating an optical device comprising a waveguide of photosensitive material, the method comprising the step of forming at least one grating structure by UV-induced refractive index variations in the waveguide; the grating structure being disposed to confine to a selected path in the waveguide light of a predetermined wavelength entering the waveguide at a predetermined angle of incidence to the grating structure.

Preferred forms of the invention will now be described, by way of example only, with reference to the accompanying drawings, in which:

Brief Description of the Drawings

Figure 1 is a schematic drawing of a device embodying the present invention.

Figure 2 is a schematic drawing of a device embodying the present invention.

Figure 3 is a schematic drawing of a device embodying the present invention.

Figure 4 is a schematic drawing of a device embodying the present invention.

Figure 5 is a schematic drawing of a device embodying the present invention.

Figure 6 illustrates in an isometric view a method of fabricating a grating confined waveguide embodying the present invention.

Figure 7 illustrates in an isometric view another method of fabricating a grating confined waveguide embodying the present invention.

Figure 8 is a schematic drawing in a cross-sectional view illustrating a device embodying the present invention.

Figure 9 is shows a plot of resonant angle against grating period for a grating confined waveguide.

Figure 10 is a schematic drawing in an isometric view illustrating a device embodying the present invention.

Figure 11 is a schematic drawing in a top view illustrating a device embodying the present invention.

Figure 12 is a schematic drawing in a cross-sectional side view illustrating a device embodying the present invention.

Figure 13 is a schematic drawing in an isometric view of a resonator structure embodying the present invention.

Figure 14 is a schematic drawing in an isometric view of a device embodying the present invention.

Detailed Description of the Preferred Embodiments

Turning initially to Fig. 1, there is illustrated schematically a first example embodiment wherein a

waveguide 1, down which light 2 is to be projected,
undergoes a tight bend in the desired path. In the
vicinity of the tight bend, a grating structure 4 is
written. The grating structure 4 effectively has a
5   photonic band gap preventing the effervescent light 2 from
leaking out and resulting in higher efficiency in the light
coupled to output 5. This results in a substantial
reduction in the bending loss as a result of the
utilization of the defraction grating 4 which in turn
10   allows for tighter bends to be formed in the waveguide
structure. The wavelength of the grating 4 can be tuned so
as to match desired frequencies for operation.

      Alternatively, as illustrated in Fig. 2, the
grating 6 can be written in a reflection mode so as to
15   provide for reflection of desired frequencies along the
path 7 with losses 8 for those frequencies not having
desired characteristics.

      The utilization of the arrangement of Fig. 2 can
be extended so as to provide for wavelength division
20   multiplexing capabilities on a waveguide structure. This
is illustrated in Fig. 3 wherein initial light can be
launched down a waveguide having a number of frequencies
$\lambda1$, $\lambda2$, $\lambda3$ coupled out of the waveguide by utilization of
corresponding matched Bragg gratings 12, 13, 14 which
25   operate so as to filter out the requisite frequencies.

      Fig. 4 illustrates a further arrangement whereby
light coupled along waveguide 15 will be coupled to outputs
16, 17 by means of suitably matched Bragg grating 18 having
desired periodic characteristics, matched to the desired
30   frequencies for coupling. The surrounding waveguide
refractive index regions eg. 19 can be tapered to provide
for stronger coupling. Preferably, the splitter
arrangement of Fig. 4 has a Bragg grating coupled such that
50% of the light traverses along each of path 17, 18. This
35   can be achieved for wavelengths twice the Bragg period. Of
course, it is possible to adjust the Bragg period to adjust
the output angle and coupling efficiency.

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Similarly, in Fig. 5 a Bragg grating 20 is provided for coupling around a bend for light travelling along the path 21, 22.

5   In Figure 6, a waveguide 110 in the form of a layer of photosensitive material has been deposited onto a substrate 112, eg. a silicon wafer having a native oxide layer for optical isolation of the waveguide material 110.

A UV beam 116 from a UV source 114 is focussed

10   (through optical elements 118) in the plane of the waveguide 110. The substrate 112 can be laterally moved as indicated by arrows 120 and 122 to effect writing of planes indicated by lines 124 of a first grating 126 of a grating structure 127, through UV-induced changes of the refractive

15   index of the waveguide 110.

After completion of the first grating 126, a second grating 128 of the grating structure 127 is written by appropriate moving of the substrate 112.

Light of a predetermined wavelength entering the

20   waveguide 110 at predetermined angles of incidence on the gratings 126, 128 are confined to a path extending in the propagation direction 130 in the plane of the waveguide 110. The propagation characteristics of the waveguide 10 will therefore depend on the wavelength of a light signal

25   131 and an angle θ under which it enters the waveguide 110.

It is noted here, that in the planar structure described above the grating confinement is limited to one-dimension in the plane of the waveguide 110. However, it will be appreciated that waveguides can be produced in a

30   photosensitive waveguide material that are grating confined in two or three dimensions.

For example, as illustrated in Figure 7, holographic UV grating writing techniques using a phase mask 140 can be used to produce a waveguide 142 (propagation direction as

35   indicated by arrow 141) within a block 144 of

photosensitive waveguide material which is grating confined
in two dimensions through gratings 146, 148 of a first
grating structure 147 and gratings 150, 152 of a second
grating structure 151 respectively.

It is noted that the one or more of the grating
structures of a device could alternatively comprise a
continuos grating whilst still effecting confinement of
light of a predetermined wavelength entering at a
predetermined angle of incidence on the grating structure.

E.g. the resonator 250 shown in Figure 14 comprises
two continuos grating structures 252, and 254 to effect
channelling of light 256 of a predetermined wavelength
entering the resonator 250 at a predetermined angle of
incidence on the grating structures 252 and 254 around a
ring path 258.

Grating confinement can also be achieved in an optical
fibre, e.g. using a cylindrical grating structure 320
around a guiding core 322 (propagation direction
perpendicular to the drawing plane) of an optical fibre 324
as illustrated in Figure 12. The grating structure 320
effects confinement to a path extending in the propagation
direction of light of a predetermined wavelength entering
at a predetermined angle of incidence on the grating
structure 320.

It will be appreciated by a person skilled in the art
that for a non-cylindrical grating structure confinement
conditions can vary in different radial directions.

The underlying principle of grating confined waveguide
propagation is the Bragg condition. For a ray travelling
in a medium of index n, peak reflectivity occurs when the
wavelength λ satisfies:

$$\lambda = 2n\Lambda\theta / m \tag{1}$$

where m is the diffraction order of the grating and θ
is the angle of the ray with respect to a single groove of
the grating. This single equation contains within it the

entire properties of grating confinement such as e.g. so-
called photonic crystal fibres.

Figure 8 shows the plot of resonant angle against
grating period for the wavelength regime 1200-1600 nm for
5   1st, 2nd and 3rd order grating diffraction. At longer
periods, variations in the resonant angle converge to
within a few degrees, although the effect is largest for
the 1st order. The physical interpretation is that for a
large number of wavelengths the incident angle is
10   approximately the same equating with similar diffraction
properties. Therefore grating confinement will occur over
a large bandwidth for a small input coupling angle at
longer periods under identical launch conditions. Outside
this regime radiation loss will occur.

15   Other interesting properties are noted. There exist
other regimes of incident angle at which total internal
reflection can occur to enable propagation along the
grating confined waveguide. Light coupled into higher
diffraction orders at much larger incident angles can also
20   satisfy the Bragg relation, giving rise to higher order
bandgaps. The effective coupling strength is reduced for
higher order mode propagation in these regimes and is
therefore characterised by larger mode areas. Since the
effective index is different, it is possible to have
25   fundamental-like mode behaviour simultaneously with
different propagation properties. Thus e.g. photonic
fibres have interesting launch regimes which are unlike
conventional effective index fibres. These regimes exist
because there are angular photonic bandgaps at which light
30   cannot propagate through the surrounding grating cladding.
Further, these bandgaps are robust and do not change much
in angular properties with increasing period and will
therefore be relatively insensitive to bend loss at longer
periods.

The angular photonic bandgap is described by the
angular reflectivity of the grating. This reflectivity
bandwidth can be extremely small, depending upon the
dimensions of the grating, its coupling coefficient, and
the angle of incidence. For either normal (incident angle,
$\theta = 90°$) or angled incidence, the power reflectivity is
given from coupled mode theory as

$$R = \left| \frac{K \sinh SL}{S \cosh SL + i\Delta\beta \sinh SL} \right|^2 \tag{2}$$

where

$$S \equiv \sqrt{K^2 = (\Delta\beta)^2} \tag{3}$$

K is the angle-dependent coupling coefficient for the
grating, L is the length of the grating and $\Delta\beta$ is the
detuning of the wavevector, defined by

$$\Delta\beta = \frac{m\pi}{\Lambda} - \frac{2\pi n}{\lambda} \sin\theta \tag{4}$$

Peak reflectivity occurs for $\Delta\theta = 0$ and declines as $\Delta\theta$
exceeds the magnitude of K. It is readily shown in grating
confined waveguides that the angular acceptance of the
reflectivity narrows considerably, with deviation away from
near normal incidence (as indicated by the decreasing slope
of Figure 8). Consequently, the higher order photonic
bandgaps will be broader and less spatially selective and
this may have implications for the robustness of singlemode
operation for large input angles. The variation of
detuning $\delta(\Delta\beta)$ with angle $\delta\theta$ is easily calculated from
above:

$$\frac{\delta(\Delta\beta)}{\delta\theta} \approx -\frac{2\pi n}{\lambda} \cos\theta \tag{5}$$

From this sensitivity to the capture angle it is
possible to vary the angular dispersion significantly by
appropriate selection of the period. Since the angle of
incidents are similar at longer periods (Figure 8) the

propagation constants, and therefore the sensitivity to capture angle, tend to converge with increasing grating period - it is therefore possible to achieve a dispersion flattened profile of the type found numerically.

Note that even for light guided solely under the effective index picture when the core index is higher than the surrounding cladding, unless the mode vector has an angle resonant with that of the grating, light can quickly couple to radiation modes and leak out. Further, this intolerance to the mode angle gives rise to the high spatial selectivity of these angular bandgaps such that single-moded propagation is robust especially for long grating periods. The mode profiles that are supported will therefore resemble the geometric positioning of the gratings radially around the core region and should differ from conventional waveguide guidance where such strict restrictions do not exist.

By recognising the importance of diffraction in a periodic lattice it is easily shown that grating confined propagation is readily achieved in so-called photonic crystal fibres. Further, the associated angular photonic bandgaps are responsible for a range of phenomena that distinguish these fibres from conventional effective index fibres. Extending the applications to resonators made up of these fibres, very interesting behaviour is predicted to occur as a result of the strict vector angles of the propagating modes, including ring-like resonances when the end reflectors are tilted. The polarisation properties of such structures may also differ to conventional resonators and an entire new class of passive and active filters and resonators are possible.

In Figure 9, a resonator 181 can be utilised for WDM (wavelength division multiplexing) filtering if the grating periods (which may be chirped) of gratings 182 and 184 of a first grating structure 183 and of gratings 186 and 188 of

a second grating structure 187 are carefully selected such that a ring resonance is different for different wavelengths and therefore the outputs are spatially at different points. This is schematically illustrated by paths 190, 192 and example outputs 194, 196. The grating structures 183 and/or 187 may be sampled grating structures.

Complex design with the use of sampled profiles etc. can be used to achieve WDM operation. In particular the angular dependence means that it may be possible to get much more closely spaced peaks with higher contrast than conventional normal incidence. It is noted that this is also applicable to fibre (e.g. photonic crystal fibres) geometries.

As illustrated in Figure 10, in a resonator laser design 300 a photonic crystal fibre 302 is located in line in a ring laser 304 (of any sort) to improve both linewidth, laser stability and mode selectivity (including transverse if multi-mode active fibre is used to increase power). It is noted that a similar design can be applicable to linear lasers (of any sort).

As illustrated in Figure 11, in an alternative embodiment, a helical ring fibre laser 310 comprises an optical fibre 312 having a grating confined core structure 314 and spaced apart concave reflectors 315, 316 within the core structure 314. The helical ring fibre laser 310 can thus provide a circularly birefringent output (as indicated by arrow 311).

Furthermore, high power fibre lasers may be provided without using cladding pump configuration. For such lasers, single mode operation and good stability are possible, as well as large mode areas. In such embodiments, the modes are grating diffraction dependent unlike conventional fibres which are aperture diffraction dependent.

It will be appreciated by a person skilled in the art
that numerous variations and/or modifications may be made
to the present invention as shown in the specific
embodiments without departing from the spirit or scope of
5   the invention as broadly described. The present
embodiments are, therefore, to be considered in all
respects to be illustrative and not restrictive.

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The claims defining the invention are

1. An optical device comprising:
- a waveguide structure;
- at least one grating structure formed in the waveguide structure; and

the grating structure being disposed to direct along a selected path in the waveguide structure light of a predetermined wavelength entering the waveguide structure at a predetermined angle of incidence to the grating structure.

2. A device as claimed in claim 1, wherein the waveguide structure is incorporates a photosensitive material, and the grating structure is formed by UV-induced refractive index variations in the photosensitive material.

3. A device as claimed in any one of the preceding claims, wherein the grating structure comprises a chirped grating.

4. A device as claimed in any one of the preceding claims, wherein the grating structure comprises a sampled grating.

5. A device as claimed in any one of the preceding claims, wherein the grating structure is disposed to direct the light in a reflection mode.

6. A device as claimed in any one of the preceding claims, wherein the grating structure is disposed to direct the light in a transmission mode.

7. An optical device comprising:
- a waveguide of photosensitive material;
- at least one grating structure formed by UV-induced refractive index variations in the waveguide; and

the grating structure being disposed to confine to a selected path in the waveguide light of a predetermined wavelength entering the waveguide at a predetermined angle of incidence to the grating structure.

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8. A device as claimed in claim 7, wherein the grating structure comprises a continuos grating.

9. A device as claimed in any one of claims 7 to 8, wherein the grating structure may comprise two gratings which mirror each other.

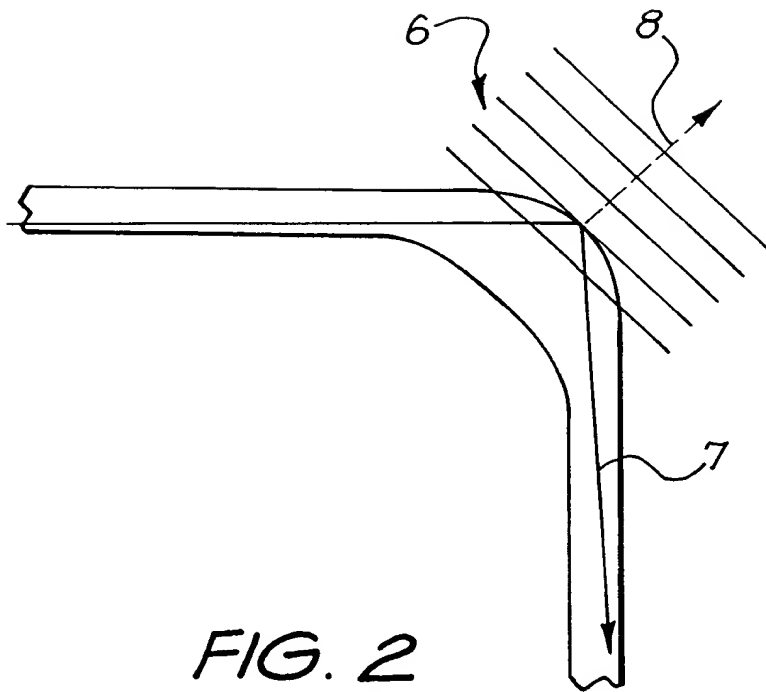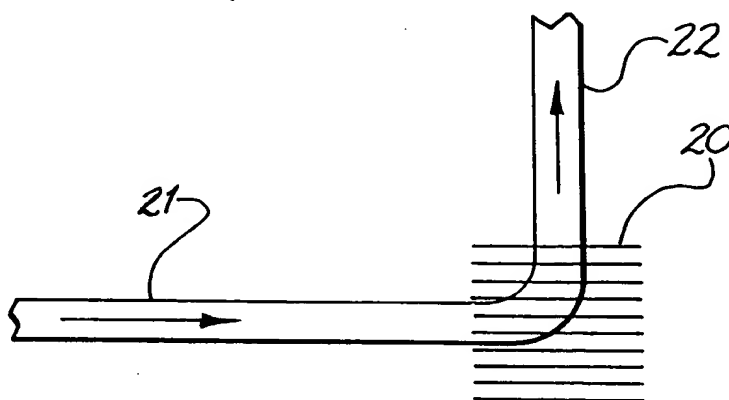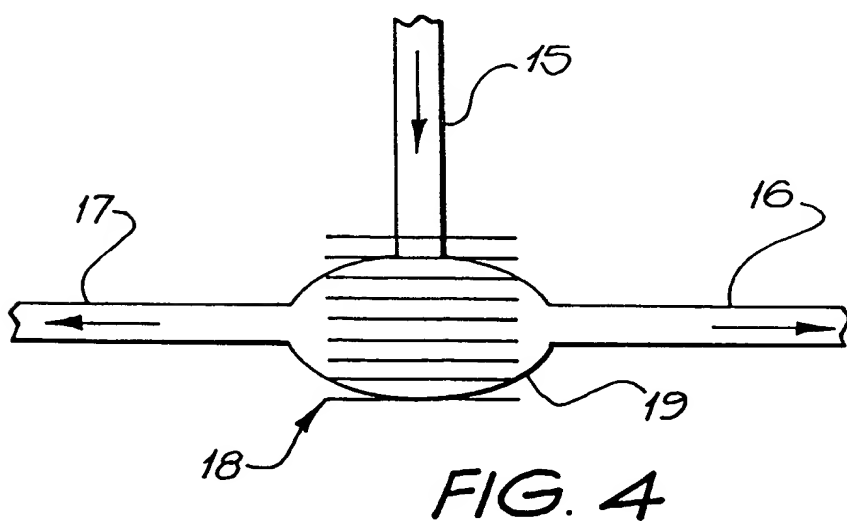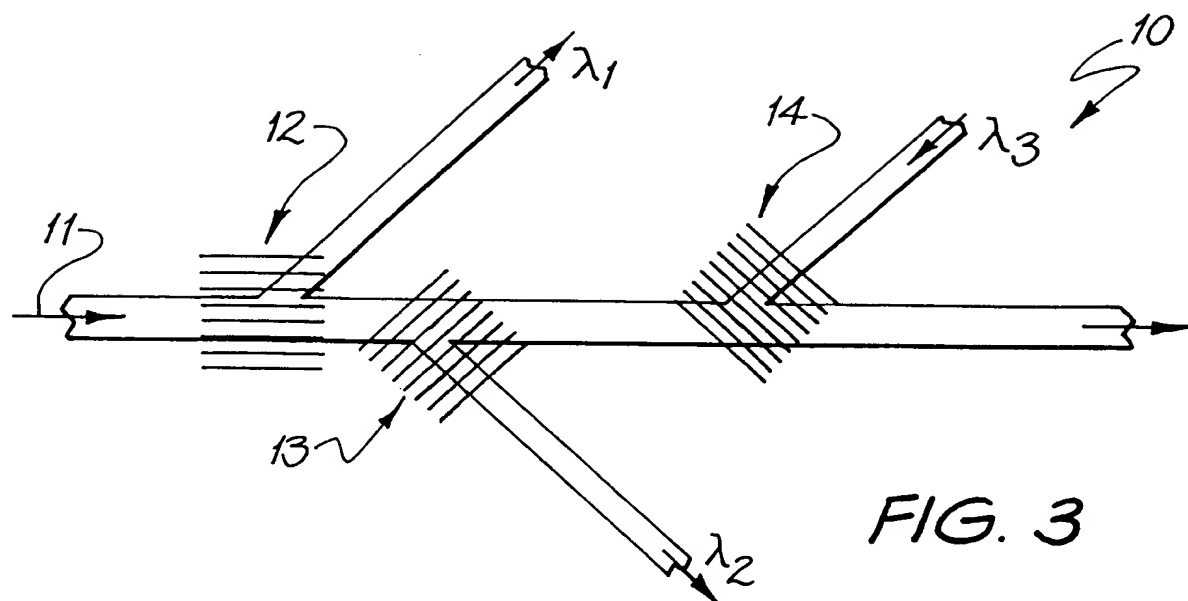10. A device as claimed in any one of claims 7 to 9, wherein the grating structure comprises regions of constant refractive index which extent in the propagation direction of the waveguide.

11. A device as claimed in claim 10, wherein the regions extend parallel to the propagation direction.

12. A device as claimed in claim 11, wherein the regions may extend cylindrically parallel to the propagation direction.

13. A device as claimed in claim 11, wherein the regions may extend elipsoidically parallel to the propagation direction.

14. A device as claimed in any one of claims 7 to 13, wherein the device further comprises at least one optical reflector disposed in a direction transverse to the propagation direction to aid in confining the light to the path.

15. A device as claimed in any one of claims 7 to 14, wherein the device comprises two or more grating structures angularly disposed with respect to each other to channel the light around the selected path.

16. A device as claimed in any one of claims 7 to 15, wherein the grating structure or structures are formed by UV-holography.

17. A device as claimed in any one of claims 8 to 16, wherein the grating or gratings are chirped.

18. A device as claimed in any one of claims 8 to 17, wherein the grating or gratings are sampled.

19. A device as claimed in any one of claims 7 to 18, wherein the device is a sensor further comprising means for

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measuring an intensity of the light at a predetermined
point along the selected path for determining changes in
the intensity due to induced changes in confinement
conditions of the sensor.

5   20.   A process for fabricating an optical device
comprising a waveguide of photosensitive material, the
method comprising the step of:

        - forming at least one grating structure by UV-induced
refractive index variations in the waveguide; and

10   the grating structure being disposed to confine to a
selected path in the waveguide light of a predetermined
wavelength entering the waveguide at a predetermined angle
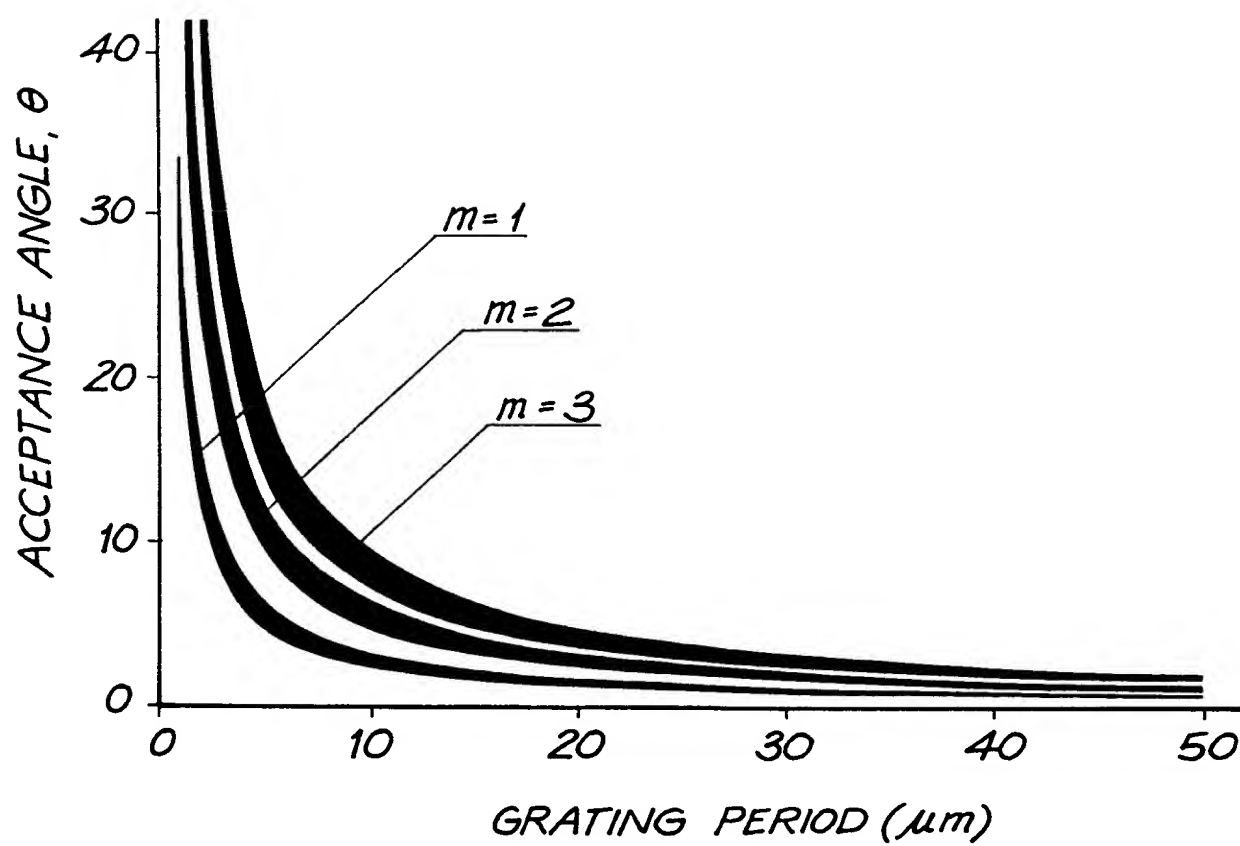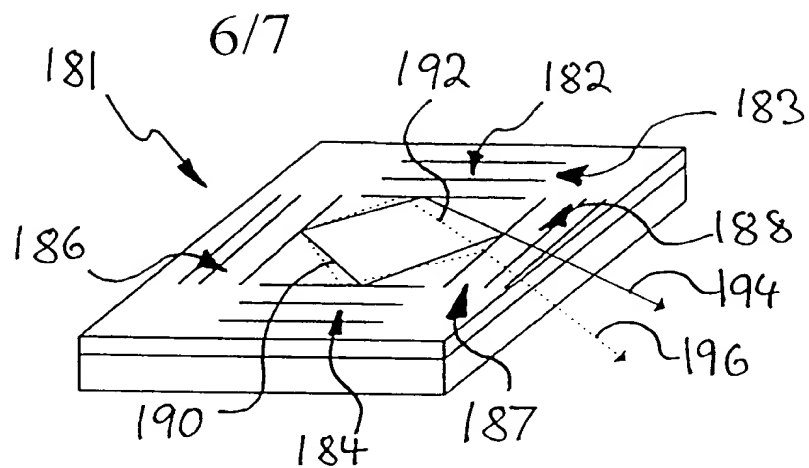of incidence to the grating structure.

FIG. 1

FIG. 2

FIG. 3

FIG. 4

FIG. 5
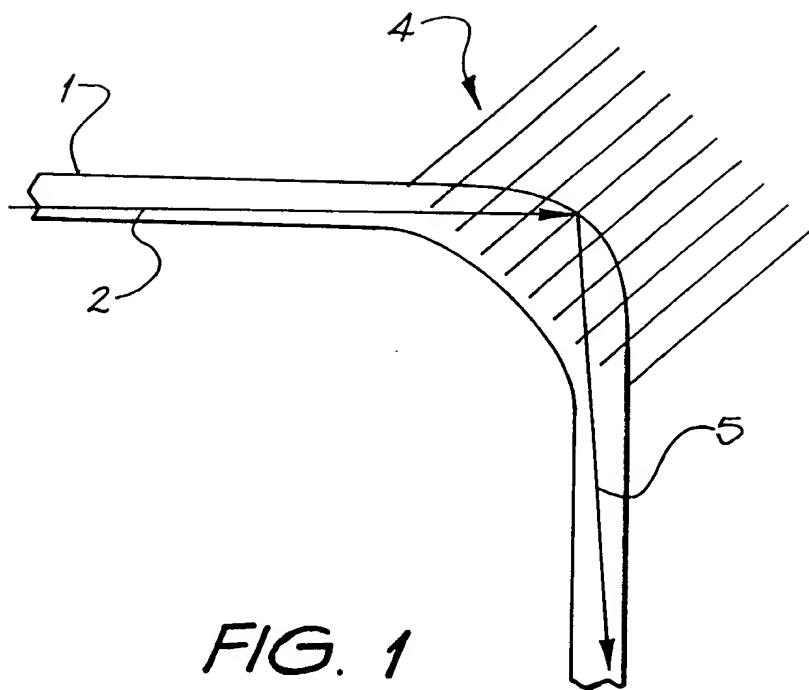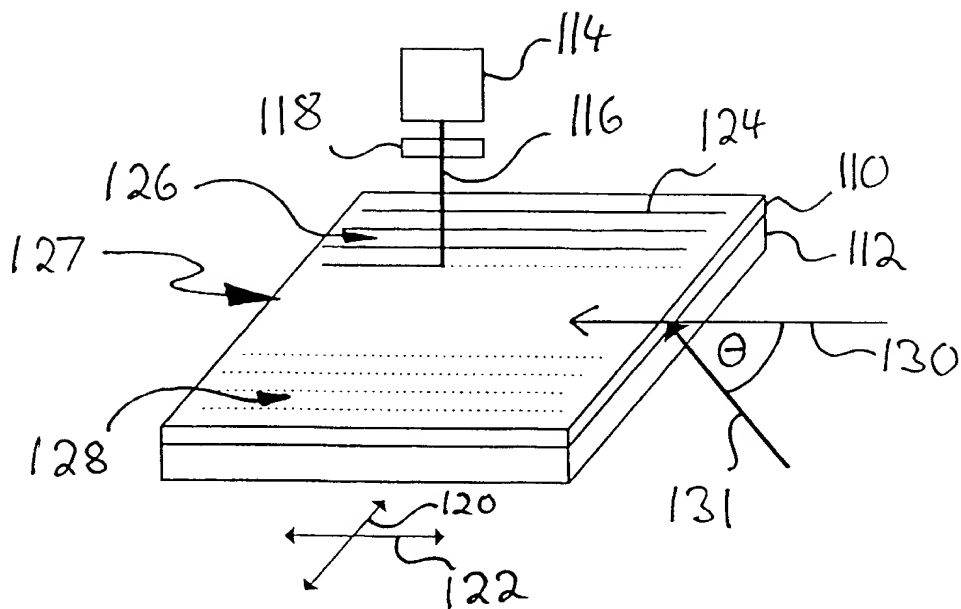
Figure 6

Figure 7

FIG. 8

6/7
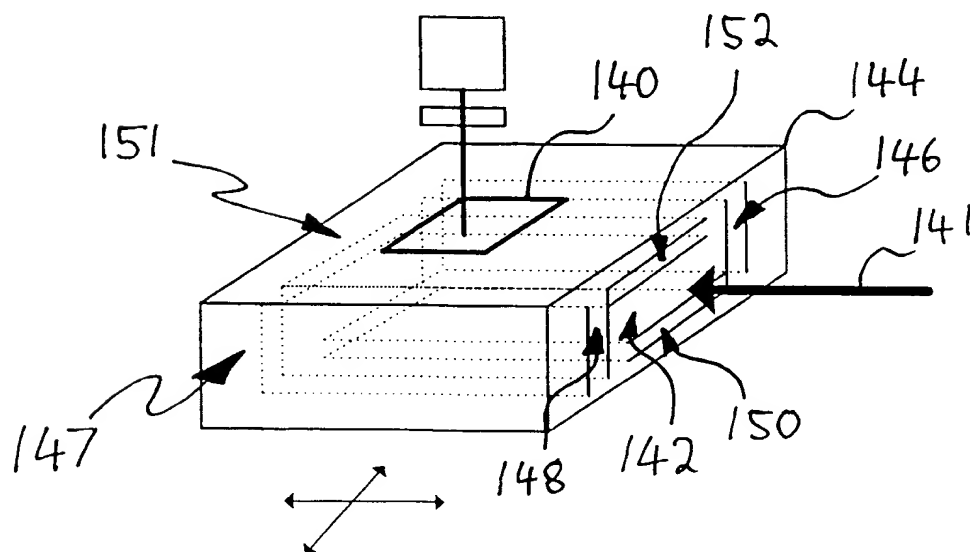
Figure 9

Figure 10

Figure 11

320

324

322

Figure 12

212

200

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208

214

202

216

204

Figure 13

250

252

256

254

258
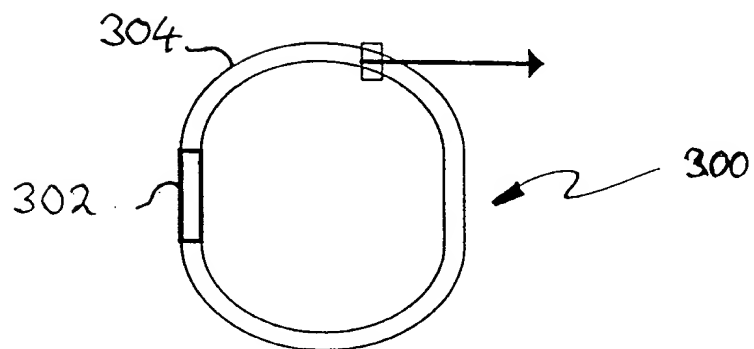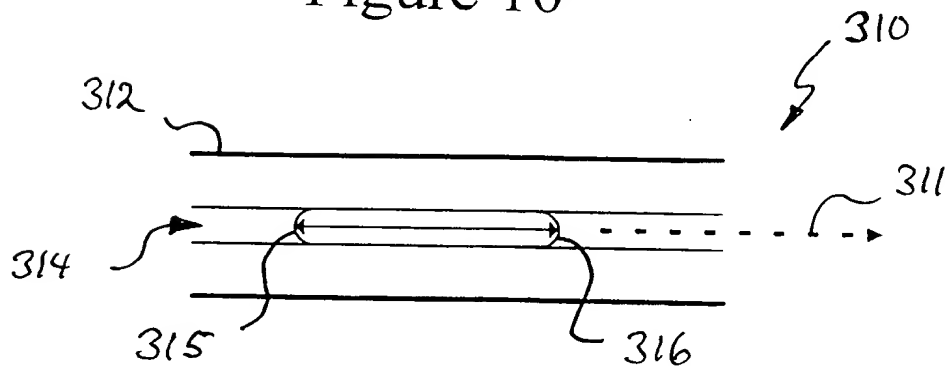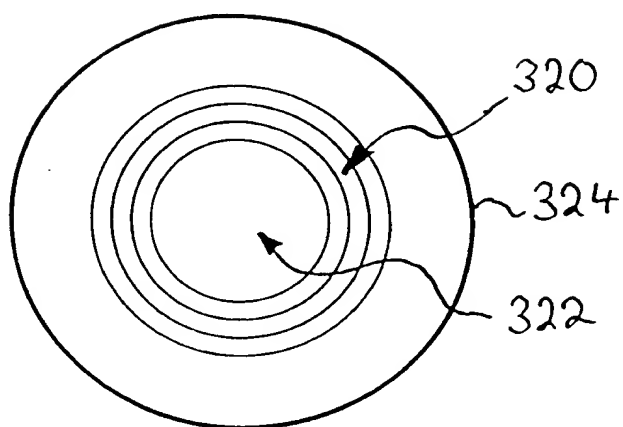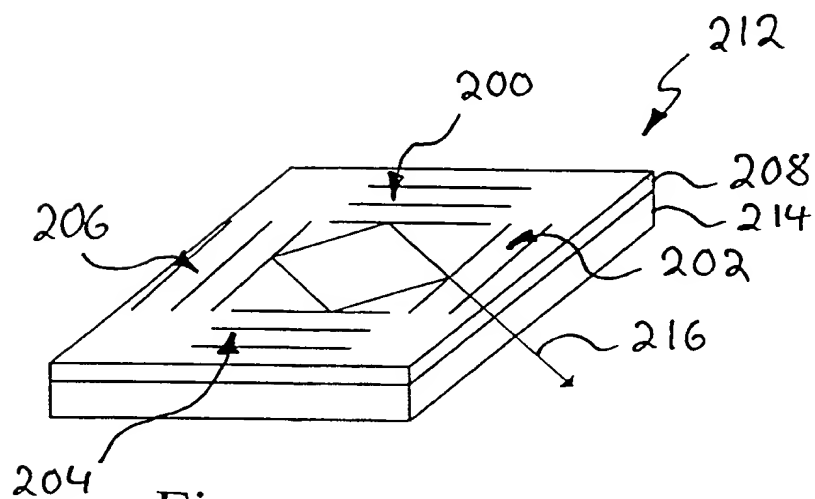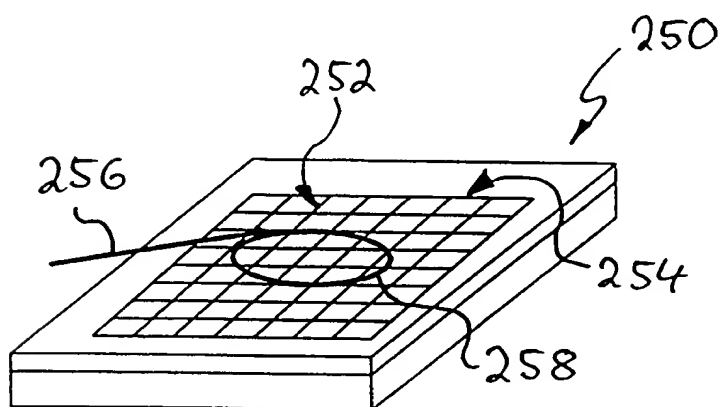
Figure 14

International application No.

PCT/AU 99/01000

A.	CLASSIFICATION OF SUBJECT MATTER

Int Cl6:   G02B 6/18, 6/10, 5/26, 5/28, 5/18

According to International Patent Classification (IPC) or to both national classification and IPC

B.	FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC: G02B 5/IC, G02B 6/IC; H04J 14/02

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
AU: IPC as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
WPAT: IPC as above with keywords: (WAVEGUIDE or FIBER or FIBRE) and GRATING and (INCIDEN:
JAPIO: or ENTER:or ENTRY) and (ANGLE or ANGULAR or BENT or BEND# or BENDING) and
(WAVELENGTH or FREQUENCY)

C.	DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5307437 A (FACQ et al) 26 April 1994 whole document	1-11,16-20
X	US 4874216 A (UTAKA et al) 17 October 1989 First and Third Embodiment, Figures 2, 3, 5	1,6
X	US 4743087 A (UTAKA et al) 10 May 1988 Figures 1, 2	1,3-6

[X] Further documents are listed in the continuation of Box C   [X] See patent family annex

*	Special categories of cited documents:	"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A"	Document defining the general state of the art which is not considered to be of particular relevance		
"E"	earlier application or patent but published on or after the international filing date	"X"	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"L"	document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"Y"	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"O"	document referring to an oral disclosure, use, exhibition or other means		
"P"	document published prior to the international filing date but later than the priority date claimed	"&"	document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
24 December 1999	10 JAN 2000

Name and mailing address of the ISA/AU	Authorized officer
AUSTRALIAN PATENT OFFICE PO BOX 200 WODEN ACT 2606 AUSTRALIA E-mail address: pct@ipaustralia.gov.au Facsimile No.: (02) 6285 3929	M.E. DIXON Telephone No.: (02) 6283 2194

	International application No.
	PCT/AU 99/01000

C (Continuation).   DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	GB 2222891 A (STC PLC) 21 March 1990 whole document	1,3,5
X	EP 672924 A (FUJITSU LIMITED) 20 September 1995 Figures 3, 11	1,5
X	EP 310438 A (BRITISH TELECOMMUNICATIONS PLC) 5 April 1989 whole document	1-8,16-18,20
X	Derwent Abstract Accession No: 89-171547/23, Class P81, SU 1418634 A (DERYUGIN) 23 August 1988 abstract	1

This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document Cited in Search Report				Patent Family Member				
US	5307437	CA	2064309	EP	506546	FR	2674639
		JP	5142423				
US	4874216	JP	1009414				
US	4743087	JP	60260024				
GB	2222891	EP	365125	JP	2176606	US	5029981
EP	672924	JP	7253519	US	5477363		
EP	310438	AU	24888/88	US	4946245	WO	89/03056

END OF ANNEX

PATENT COOPERATION TREATY

PCT

INTERNATIONAL PRELIMINARY EXAMINATION REPORT   PCT

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference FP11653	**FOR FURTHER ACTION**	See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416).

International Application No. **PCT/AU99/01000**	International Filing Date *(day/month/year)* 12 November 1999	Priority Date *(day/month/year)* 12 November 1998

International Patent Classification (IPC) or national classification and IPC

Int. Cl. ^{7} G02B 6/18, 6/10, 5/26, 5/28, 5/18

Applicant

   THE UNIVERSITY OF SYDNEY et al

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1.   This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.

2.   This REPORT consists of a total of   3   sheets, including this cover sheet.

   [X]   This report is also accompanied by ANNEXES, i.e., sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

   These annexes consist of a total of   **5**   sheet(s).

3. This report contains indications relating to the following items:

   I   [X]   Basis of the report

   II   [ ]   Priority

   III   [ ]   Non-establishment of opinion with regard to novelty, inventive step and industrial applicability

   IV   [ ]   Lack of unity of invention

   V   [X]   Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

   VI   [ ]   Certain documents cited

   VII   [ ]   Certain defects in the international application

   VIII   [ ]   Certain observations on the international application

Date of submission of the demand 31 May 2000	Date of completion of the report 12 December 2000
Name and mailing address of the IPEA/AU AUSTRALIAN PATENT OFFICE PO BOX 200, WODEN ACT 2606, AUSTRALIA E-mail address: pct@ipaustralia.gov.au Facsimile No. (02) 6285 3929	Authorized Officer **M.E. DIXON** Telephone No. (02) 6283 2194

Form PCT/IPEA/409 (Cover sheet) (July 1998)

I.	**Basis of the report**

1. With regard to the **elements of the international application:*

☐ the international application as originally filed.

☒ the description,   pages **4-12,**   as originally filed,

       pages , filed with the demand,

       pages **1-3,** received on **21 November 2000** with the letter of **20 November 2000**

☒ the claims,   pages , as originally filed,

       pages , as amended (together with any statement) under Article 19,

       pages , filed with the demand,

       pages **13, 14,** received on **21 November 2000** with the letter of **20 November 2000**

☒ the drawings,   pages **1/7-7/7,** as originally filed,

       pages , filed with the demand,

       pages , received on with the letter of

☐ the sequence listing part of the description:

       pages , as originally filed

       pages , filed with the demand

       pages , received on with the letter of

2. With regard to the **language**, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.
These elements were available or furnished to this Authority in the following language which is:

☐ the language of a translation furnished for the purposes of international search (under Rule 23.1(b)).

☐ the language of publication of the international application (under Rule 48.3(b)).

☐ the language of the translation furnished for the purposes of international preliminary examination (under Rules 55.2 and/or 55.3).

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, was on the basis of the sequence listing:

☐ contained in the international application in written form.

☐ filed together with the international application in computer readable form.

☐ furnished subsequently to this Authority in written form.

☐ furnished subsequently to this Authority in computer readable form.

☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.

☐ The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished

4. ☒ The amendments have resulted in the cancellation of:

     ☐ the description,   pages

     ☒ the claims,   Nos. **18-20**

     ☐ the drawings,   sheets/fig.

5. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed, as indicated in the Supplemental Box (Rule 70.2(c)).**

* *Replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report since they do not contain amendments (Rules 70.16 and 70.17).*

** *Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report*

V.	**Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement**

1. Statement

	Novelty (N)	Claims	**1-17**	**YES**
		Claims		**NO**
	Inventive step (IS)	Claims	**1-17**	**YES**
		Claims		**NO**
	Industrial applicability (IA)	Claims	**1-17**	**YES**
		Claims		**NO**

2.   Citations and explanations (Rule 70.7)

The invention as defined in the independent claims is an optical waveguide structure comprising an optical waveguide having a bend and being formed of photosensitive material and with a grating structure comprising UV-induced refractive index variations and arranged to guide light of a predetermined wavelength around the bend (claim 1); and a method of adapting such a waveguide to guide light of predetermined wavelength around a bend in the waveguide by using UV light to induce refractive index variations in the waveguide such that a grating is formed and is disposed to guide light around the bend (claim 17).
The remaining claims are appended and define further preferred features.

The closest cited art is US 4874216 and relates to an optical branching filter in which a diffraction grating is formed in the cross region of two crossing waveguides to branch light of a particular wavelength to a desired one of the waveguides. However, this document does not disclose a waveguide of photosensitive material nor does it teach a grating structure comprising UV-induced refractive index variations in the waveguide.

None of the remaining citations discloses the features claimed.

Therefore the claims comply with Article 33(2)-(4).